ANNALS
OF THE UNIVERSITY OF STELLENBOSCH

Edited by
PROF. C. A. DU TOIT
Co-editors:
PROF. D. L. SCHOLTZ, PROF. B. TAUTE and PROF. R. W. WILCOCKS

Volume XXVI, Section A, No. 13 (1950)

VIRUS DISEASES AND SOME SYMPTOMOLOGICALLY RELATED ABNORMALITIES OF THE VINE

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ABSTRACT

SEVERAL diseases of the vine known or suspected to be caused by viruses had been studied during 1949 in North America and in several European countries. Several distinct abnormalities of the vine were examined.

The Pierce's disease of the vine, seen in California and recently reported to occur in the Argentine, causes a mottling, malformation, puckering and premature drop of the leaves, a premature drop of blossoms, premature colouring of the berries, retarded growth and ultimate die-back of the vines.

Roncet (urticado, nettle leaf or reisigkrankheit), the disease previously mostly designated as court-noué, occurs in California, Portugal, Spain, France, Switzerland, Italy (including Sicily) and in Germany. Leaf mottling and double leaves are rare; but the leaf indentations become so pronounced that bramble-like, nettle-like or parsley-like leaves are formed on severely affected vines. The growth of affected vines is stunted, nodes are shortened, in some cases doubled, and coulure and millerandage are severe at a very early stage of the disease. The latter symptoms are however not characteristic for this disease only.

The general or blotchy albinosis of vine leaves is the most striking symptom of white mosaic or panachure. The leaves on affected vines retain their normal shape, but the growth is stunted and infertility severe. This disease occurs in California, Portugal, Spain, France, Switzerland and Italy, and according to reports also in several countries of central Europe.

Very typical mosaic symptoms were observed on the leaves of some vines infected with true mosaic in France, Switzerland and Italy. On these irregular light green, cleared areas occur and sometimes so extensively that normal dark green islands are formed on the leaves of affected vines. The growth of these vines is stunted and infertility is severe.

The rolling in of the sides and tips of leaves is the most characteristic leaf symptom of the rollerkrankheit or leaf roll. This condition occurs in French, Swiss, German and South African vineyards. Some uncertainty still exists about the cause and importance of this disease.

A disease for which the name " witches' broom " is proposed was examined in Switzerland. The growth of the affected vines is severely stunted; the leaves are dwarfed, pale green in colour and severely scorched along the margins and in the interveinal areas. Short internodes, double nodes and shoot fasciation are some very distinct shoot symptoms. It's appearance and spread in the Rhone Valley and near lake Zürich is very suggestive of an infectious and possibly a virus disease. A very similar condition had been described in Spain to be the result of attacks by *Empoasca lybica*.

A severe malformation, rolling and general distortion of leaves and signs of nanism and gigantism on shoots occur in a very striking manner on Berlandieri vines in Sicily. This condition appeared to be systemic and suggestive of a virus disease. The name " distortion disease " had been suggested for this disease.

The leaf malformations resulting from applications of weed-killers or arising under natural conditions, presumably as a result of natural hormone disturbances, differ distinctly from those associated with any of the diseases previously mentioned. Short internodes, double nodes, fasciation of shoots, infertility, coulure and millerandage are associated phenomena. These abnormalities are, however, common for several diseases. However, the leaf symptoms caused by hormone disturbances are so characteristic and so distinctly different from those of roncet, that the two abnormalities are not analogous.

Clear distinction between these different abnormalities of the vine is an important preliminary to further study. For this reason it is considered that a recent decision to use the all inclusive designation of " dégénérescence infectieuse " is rather unfortunate. For the same reason the names roncet (urticado, nettle leaf or reisigkrankheit) is suggested in preference to court-noué.

CONTENTS

INTRODUCTION.

Recent reports on several diseases of the vine shown to be of a virus origin have stressed the importance of these diseases in different vine growing countries of the world and have indicated that the losses caused by them in many cases have assumed alarming proportions.

A very intimate knowledge of the South African vineyards gained by his studies on several vine diseases since 1933, has led the author to conclude that the South African vineyards are still free from some of the most devastating virus diseases occurring in North America and in Europe. South African viticulture is therefore in a highly privileged position and every effort must be made to preserve this happy state of affairs.

It was to this end that the Department of Agriculture of the Union of South Africa wisely sent the writer overseas to investigate the various aspects of virus diseases in the United States of America, Canada, Portugal, Spain, France, Italy, Switzerland and Germany.

Although primarily interested in the appearance, distribution and effects of these diseases, the author also became keenly interested in the problems which exist in connection with their diagnosis, and most particularly with those experienced in connection with the court-noué-complex or " dégénérescence infectieuse ". The author enjoyed the privilege of discussing vine virus problems with leaders in this field of research. He was in the unique position of having collected the up-to-date opinions and findings of the world authorities and it was suggested that he should publish an article on the position as it exists to-day. It is with pleasure that he responds to this suggestion as a tribute to the co-operation and hospitality enjoyed by the author at all the institutions which he visited.

REVIEW OF THE LITERATURE.

Pierce's disease was first observed in the vineyards of Southern California during 1884 (Pierce, 1892) and up to 1895 it was estimated to have caused the destruction of approximately 30,000 acres of vineyards. After that the losses caused by the disease apparently declined and caused relatively little concern until 1927. It was then found that it had spread to nearly all the vine-growing areas of California (Hewitt et al. 1942). The destruction caused by the disease increased rapidly from 1935 to 1942 (Winkler et al. 1949) since when it has declined. In 1939 Hewitt (1939) reported that he had succeeded in transmitting the disease by root grafting and budding. Subsequently he and his associates found that the causal virus was transmitted by several species of leaf hoppers, that the virus causing Pierce's disease was similar to lucerne dwarf disease, and transmissible from lucerne suffering from dwarf disease (Hewitt et al. 1942, 1946), and that the host range of the virus included 73 species in 20 families, ranging from grass to shrubs (Winkler 1949). Recently Vitoria and Alcaldo Lassalle (1949) reported on an " arrugamiento viroso " investigated in Mendoza and San Juan, Argentine, since 1941 and found it to be identical with Pierce's disease. The losses caused by this disease ranged from 50 to 100 per cent. *Convolvulus arvensis* was mentioned as one of the suspected hosts of the virus.

The early literature on " roncet " or " court-noué " was very well reviewed by Pantanelli (1911). In this review he described the external symptoms of the disease as occurring in most typical form on *Vitis Rupestris* and mentioned three distinct phases of the disease:— the splitting of the leaves (*persillage* dei Francesi), the shortening of the nodes (court-noué) and a pale spotting of the leaf (mosaico della vite), each of which he apparently succeeded in propagating separately. On Berlandieri, irregularity, bollosity and mosaic were the primary leaf symptoms. The leaf splitting, short internode and mosaic symptoms all occurred on Riparia and also on the Vinifera types; the predominance of the particular symptoms of Vinifera varied with the variety. He indicated, however,

that most of the symptoms found on vines affected with roncet (shortness of internodes, dwarfing and spotting of the leaves, fasciation, sucker formation, etc.) were not characteristic of this disease, because they could also develop as a result of the action of some root parasites. Pantanelli summarized several theories, proposed by different investigators, for the cause of the disease, including bacteria, fungi, acari, virus, oxidative enzymes and various environmental factors as causal agents. He failed to obtain transmission of the disease with sap from infected plants, and, though realizing the analogy between the mosaic symptoms on the vine and those on tobacco, then decided against the virus theory in favour of a possible toxic enzyme theory.

In 1912 Petri published a very detailed description of the arricciamento (roncet) as it occurred in Sicily, and clearly depicted the laciniated foliar symptoms, the short internodes and their zig-zag arrangement typical of arricciamento, a disease which he considered to be similar to court-noué. According to him (Petri 1913) the affected vines first showed endocellular cordons, foliar deformations and ultimately the short internodes. He showed (Petri 1935, 1937) that the symptoms of arricciamento might develop on the Negro amaro vines, but that Malvasia bianca grafted on infected Negro amaro, did not show any signs of infection. Negro amaro regrafted on these Malvasia bianca, however, developed the symptoms of the disease. Malvasia bianca clearly was a symptomless carrier of the disease. In 1932 Petri reported the occurrence of a disease causing a rapid decline and premature senility of vines in Italy, a disease in which pronounced shortening of the internodes, small leaves, false side shoots and sometimes a reddening of the leaves were characteristic. It was presumed that this disease was due to a virus, though in effect distinct from arricciamento.

Meanwhile Smolak (1926) described a mosaic disease occurring in the vineyards of Melnik. Stranak, Blattny and Klecka (1931) reported that this disease had been known for over 40 years in vineyards of Czecho-Slovakia. None of the varieties seemed to be immune, though the disease was suspected to be latent in some. It could be readily transmitted by grafting, sap-injection, inoculation through wounds on the aerial or underground parts, and by certain sucking insects, e.g. *Lecanium corni* and aphids. It was not present in or transmissible by soil. Stranak and co-authors indicated that their mosaic presented some features in common with other virus diseases of the vine, more particularly roncet, but they failed to separate the mosaic from some of the acknowledged roncet symptoms. The chief characteristics of this type of mosaic were the yellowing or whitening of the principal and secondary veins, a shortening of the internodes, profound leaf lobing and false dichotomy. Petri (1932 a, b) drew attention to the fact that Pantanelli had described another form of mosaic, differing from that in Bohemia and rather similar to some cases found on vines affected by arricciamento.

Martinoff (1934), reported on a mosaic disease threatening Bulgarian vineyards and showing symptoms corresponding to those of mal nero, reisigkrankheit, roncet, court-noué, rougeau, brunnisure and apoplexie. The diversity of symptoms led him to suspect that the diseased condition was caused by a mixture of more than one virus type. He also observed that some varieties could spread the disease in a latent condition.

In 1945 Hewitt reported on a graft-transmissible mosaic disease found in California and pointed out that this disease very closely resembled the mosaic disease described on *Vitis vinifera* by Stranak et al.

Mencacci (1930) reported on yet another disease observed near Rome in which the young shoots showed symptoms resembling roncet. The leaves, however, were covered with hairs, developed small enations and became rugose. Petri and Gigante suspected a virus to be the cause of the disease, but the grafting trials by Gigante (1937) failed to transmit the disease.

Schneiders (1936) differentiated six stages in the development of reisigkrankheit, roncet or court-noué. The foliar indentations were the first to develop, followed by the formation of short internodes, double nodes, bunch malformations, leaf roll and premature discolouration, yellowish leaf mottling, progressive vine deterioration and the formation of parsley-like leaves, which became more pronounced as the disease progressed. Branas and his associates (1939 b) published some excellent descriptions and illustrations of court-noué symptoms on the bunches and shoots (short internodes,

zig-zag arrangement, double nodes and fasciation) and particularly on the leaves. Branas (1948 a, b) reported on some very clear mosaic symptoms on leaves of the hybrid 17C and reported: " La dégénérescence infectieuse de la vigne est provoquée par un complexe du virus, puisque, dans un cas, il a été possible de séparer la mosaïque de la déformation foliaire du Rupestris du Lot ". He found that the mosaic symptoms appeared more rapidly than the other symptoms, but considered that further work would be required to determine the relation of this mosaic to that described by Stranak and Martinoff.

In most of the contributions in which the symptoms of court-noué, roncet or reisigkrankheit were described, considerable emphasis was laid on the shoot symptoms, i.e. short internodes, zig-zag nodal arrangement, double nodes, fasciation, etc. However, the possibility was raised by Viala (1924), Maier and Maier (1939) and others, that these shoot symptoms might sometimes develop as a result of some other factors not responsible for the typical court-noué or reisigkrankheit.

It seems to be fairly generally agreed now that roncet, arricciamento, court-noué and reisigkrankheit are different names for the same disease. These names are most generally used in Italy France and Germany (Branas 1938 b, Anon. 1947).

Petri, in a large number of contributions on roncet (arricciamento), maintained that the presence of endocellular cordons in infected vines was one of the most characteristic and best diagnostic characters of the early stages of the disease (Petri 1913, 1918, 1932 (a, b), 1934, 1935, 1937, 1942) In 1913 Petri mentioned its transmission from scion or stocks to healthy grafts; but indicated that the formation of these cordons might be provoked by exposure to low temperatures, though neither court-noué nor foliar deformations resulted from such exposure.

When Petri (1932 a, b) examined specimens of vines from Czecho-Slovakia infected with mosaic (Stranak, Blattny and Klecka 1931), he found endocellular cordons to be present in them and decided that this was an indication of an affinity between this form of mosaic and arricciamento. Jöhnssen (1933) and Schneiders (1936) accepted the presence of endocellular cordons as the most reliable early diagnostic character of reisigkrankheit, but Maier (1939 b, 1943) after studying the occurrence of the cordons in the wood of different internodes, reported that he found them also in sound units, though apparently not as abundantly as in the wood of vines suffering from the disease. Stellwaag (1948) reported the same experience and decided that their diagnostic value for an early recognition of the disease was rather doubtful.

In 1918 Petri found that the disease might be transmitted to healthy vines by the introduction of unsterilized soil from infected localities, whereas heating of the soil to 120°C. destroyed the disease-producing capacity of infected soil. Water drained from infected soil could induce the disease when applied to healthy soil. The pathogenic action of this soil was, however, removed when filtered through a Kitsato or similar filter. He then suspected a microörganism with a plasmodial phase, possibly a protozoon, capable of existing for some time in the soil and of infecting the vine through the roots. He even found evidence of transmission by root contact (Petri 1924). Further evidence on the transmissibility of the disease by cutting and grafting and from scion to stock and vice versa was published in 1928 by Ravaz. It was then already general experience that replanting of sound vines soon after the removal of infected vines resulted in a very severe attack on the new plantings. In 1929 Petri obtained evidence in support of a theory that arricciamento or roncet, which he considered to be similar to court-noué, was caused by a virus, a conclusion which he very emphatically reiterated in 1934 (Petri 1934 b). This virus hypothesis was subsequently very strongly supported by Branas and his associates (Branas 1938 (a), 1939 (a, b), 1948 (b); Branas, Bernon and Levadoux 1937, 1939 b, 1942, 1946). In 1942 Branas, Bernon and Levadoux announced that they had succeeded in purifying a protein virus from court-noué infected vines, but proof of pathogenicity was still lacking.

Branas, Bernon and Levadoux (1937) suggested the possibility that *Phylloxera vastatrix* f. *radicicola* was one of the chief vectors of the disease in nature. The following observations and assumptions were accepted to support this view: (a) court-noué was rare before Phylloxera was introduced into vineyards of Europe (Branas 1938 a); (b) court-noué was less common in areas

relatively free from Phylloxera, such as in sandy soils or in soils subject to occasional floods (Branas 1938 c, Levadoux 1946); (c) the uprooting of vines infected with court-noué apparently accelerated the spread of the disease to neighbouring healthy vines (Branas 1939 b, 1945 b, Branas, Bernon and Levadoux 1937 b, Kuhnholtz-Lordat, 1944); (d) deep cultivation or trenching amputated vine roots whereby the insect was forced to migrate from infected to sound vines which, weakened by this amputation, became an easier prey to Phylloxera and the court-noué virus transmitted by it (Branas, Bernon and Levadoux 1939 a, Emon 1938); (e) vine varieties resistant to Phylloxera were less readily invaded by court-noué than those more susceptible to the insect (Branas, Bernon and Levadoux 1937); (f) sound vines, replanted after a lapse of several years or after other crops had been grown on soils which had borne court-noué infected vines, remained free from the disease (Branas 1938 a); (g) the sterilization of infected soil with CS_2, potassium permanganate etc. rendered the soil safe for replanting with sound vines (Branas 1938 a); (h) the severity of court-noué on soils into which Phylloxera had been artificially introduced was apparently proportional to the number of vectors introduced (Branas, Bernon and Levadoux 1946).

Lykiardopoulo (1940) reported that the disease was found to occur and to spread in vineyards in Greece where *Phylloxera vastatrix f. radicicola* did not occur. Though Limasset (1946) acknowledged that the court-noué disease assumed epidemic proportions only after the French vineyards had been invaded by *Phylloxera vastatrix f. radicicola*, a fact which supported the view that the disease might be transmitted by the insect, he considered that the other arguments put forward by Branas were unacceptable unless they were supported by extensive experiments. Galles (1946) reported on a case where court-noué had spread in a vineyard near Narbonne on soil which was subject to occasional flooding and was free from Phylloxera. Nysterakis (1947, 1948) mentioned that he had reason to doubt that Phylloxera could be a vector of the virus. It should be mentioned, however, that the evidence offered by Branas and supporters of his hypothesis, though evidently supporting his claims, is circumstantial. An attempt made by Branas, Bernon and Levadoux (1947) to find direct evidence by transferring Phylloxera from diseased to sound vines, yielded inconclusive results, though none could disprove the theory of transmission by this insect.

Rives (1923) held that an endophyte, causing the destruction of the rootlets, was responsible for court-noué. Gauch (1924) expressed the view, however, that the disease might be the result of a lack of vitamins owing to the inhibition of soil microbes by unfavourable conditions. Viala and Marsais (1934) claimed that court-noué was caused by *Pumilus medullae*, a fungus now accepted by most workers to be the cause not of court-noué, but of a decay of woody tissues leading to some types of vine senescence (Staehelin and Wurgler 1947). Michel (1948) found some court-noué symptoms to be apparently related to the copper content of soils, an experience which led him to propose that this disease probably originated as a result of the accumulation of copper in the soil resulting from continuous spraying. Raphael (1948) thought that most of the court-noué manifestations might be due to cellulolysis induced by the presence of a copper complex in the tissues. On account of similarities between some court-noué symptoms and the shoot and foliar deformations developing as a result of applications with phytohormones, Nysterakis (1945, 1947, 1948) and Topi and Baldacci (1949) expressed the view that the disease might be the result of hormone or auxin disturbances, in some cases possibly due to the action of a virus.

The experimental data obtained by most of the European workers on this disease, however, seem to support the view that the typical roncet (arricciamento, reisigkrankheit, court-noué) is caused by a virus.

Though the name " arricciamento ", sometimes used by Petri for roncet, suggests leaf-roll as one of the characteristic symptoms of the disease, it was doubted whether this phenomenon was similar to the rollerkrankheit described in Germany by Maier (1939 a) and Stellwaag and Branas (1939). These workers agreed that the type of leaf-roll and premature autumn colouring found on vines affected with rollerkrankheit were distinct from those sometimes found on vines affected with arricciamento. They expressed the view that rollerkrankheit was a transmissible virus disease. In recent discussions, however, Branas and Stellwaag had some doubts about the cause of the disease.

The diseases of the vine, known or suspected to be of virus origin, may therefore be grouped into the following categories (1) Pierce's disease ; (2) Roncet, arricciamento, reisigkrankheit or court-noué ; (3) Panachure or the mosaic of Stranak and co-workers ; (4) True Mosaic ; (5) Rollerkrankheit ; (6) Leaf enation.

Two of the symptoms previously accepted as very characteristic of the roncet disease, viz. nodal abnormalities (short internodes, double nodes and fasciation) and endocellular cordons, apparently may be induced by various factors and therefore have a doubtful diagnostic value.

VIRUS DISEASES OR PRESUMABLY VIRUS DISEASES

PIERCE'S DISEASE.

The author had the opportunity of becoming acquainted with some of the early effects of the disease on vines in California in the San Joaquin Valley, in the vicinity of Fresno, and in the Napa and Wadden Valleys, during May 1949. Though the severity of the disease had definitely declined since 1941 (Winkler, 1949), sufficient evidence could be seen of the delayed growth due to

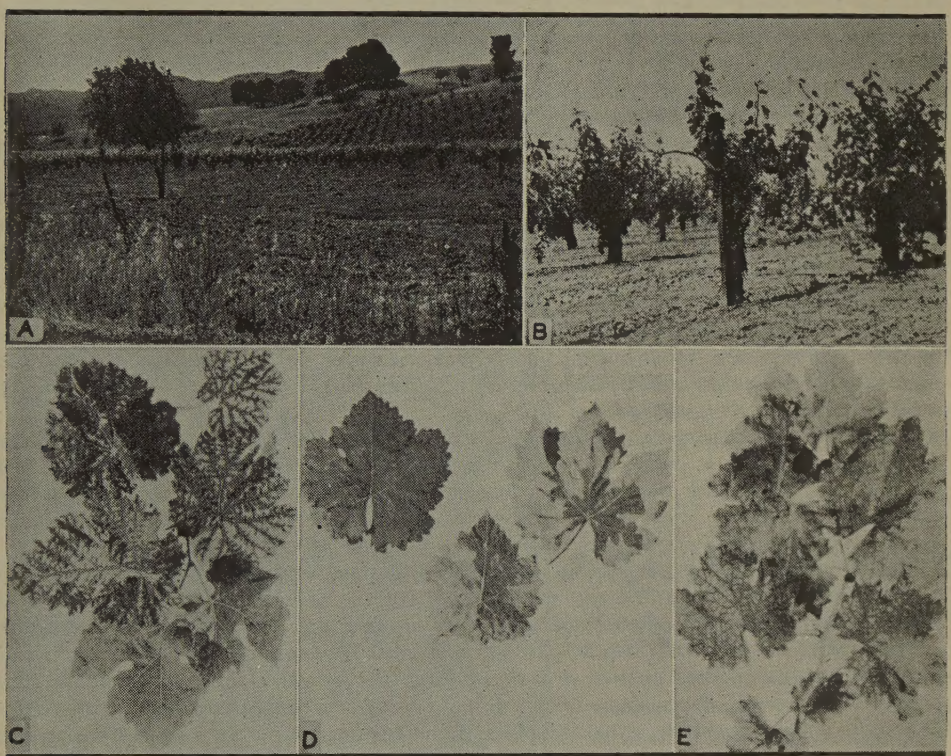

PLATE 1.—PIERCE'S DISEASE: A, *Marginal destruction of a vineyard in the Napa Valley, California, caused by Pierce's disease (24/5/1949).* B, *A grape vine in the Napa Valley affected with Pierce's disease (24/5/1949).* C, *Leaf mottling on White Malaga vines suffering from Pierce's disease in the Tulare County, California (Courtesy of Wm. B. Hewitt, June 1939).* D, *Leaves of the Palomino variety in the late stages of the Pierce's disease and drying up from their margins (Courtesy of Wm. B. Hewitt, 8/12/1949).* E, *Leaf mottling on Palomino vines affected with Pierce's disease in the Napa Valley, California (Courtesy of Wm. B. Hewitt, 30/9/1940).*

the disease on vines (Plate 1B) or in cases where the disease had spread first from vines nearest to the neighbouring natural vegetation inwards (Plate 1A).

Some early leaf mottling symptoms could be seen on some varieties, but it was then still somewhat early in the season to see specimens of the more advanced stages of leaf mottling. As Hewitt (1941) and Hewitt et al. (1942) indicated, the light green or chlorotic lesions situated between the veins progressively enlarged until most of the interveinal tissues were ultimately chlorotic, leaving only narrow strips of green tissues around the veins (Plate 1C and E). In some cases the chlorosis was confined mainly to certain portions of leaves, being most intense on the leaves at the base of the shoots and sometimes creating the impression that the vines were recovering from the disease during the latter part of the growing season.

During development of chlorosis most of the leaves retained their normal shape, though the petiolar sinuses showed a tendency to close, very often to such an extent that the lower leaf portions folded over each other to cover the sinus.

Information was received from Dr. Hewitt, however, that he and his associates were of the opinion that this leaf mottling was secondary and not directly caused by the virus. Furthermore they had collected information to show that other conditions might be the cause of types of leaf chlorosis or mottling previously associated only with Pierce's disease in Californian vineyards. They were of the opinion that the symptoms developing later in the season are more characteristic of the disease.

According to Hewitt (1941) and Hewitt et al. (1942) the chlorotic leaves in many varieties are wrinkled or puckered along the main veins, and irregular, cupped, one-sided or otherwise misshapen. Chlorotic leaves tend to burn and dry up along the margins and afterwards in between the large veins from mid-June onwards. Leaf scalding on non-mottled leaves borne by infected vines, is apt to begin at the leaf margins, and marginal and interveinal leaf areas tend to dry up while the tissues are still green (Plate 1 D). These dried up areas are usually pale brown in colour and often bordered by yellow tissues which gradually merge into the normal green of the rest of the leaf. This type of leaf scorch is apparently one of the most characteristic symptoms of the disease and is particularly noticeable towards the latter part of the season, when severe leaf scorch may result in the premature drop of the leaves, leaving the leaf petioles still attached to the cane. It was indicated by Hewitt and associates (1942), however, that some other vine troubles, e.g. measles, may result in a similar type of leaf drop, but whereas vines suffering from measles may develop leaves again, those suffering from Pierce's disease seldom do.

The disease usually causes the premature drop of the blossoms or otherwise a premature development of colour in the berries, which then tend to soften, wilt and dry up. Meanwhile the shoots die back from their tips, and ripen irregularly in autumn, apart from the general stunting effect of the disease on shoots borne by severely affected vines. Ultimately the roots die back, usually from the second season after infection.

To demonstrate the transmissibility of the disease through grafting, Hewitt adopted the bud-grafting, root-grafting and the Yammi-budding techniques, the latter on young tissues and all in the first instance on self-rooted, selected vines with sufficient check vines for comparison. For budding he preferred to use buds from infected material situated at different positions on different shoots, because he had experienced that the virus is not necessarily present in the shoots or in particular buds. After successful transmissions on this variety the virus was then transmitted to other varieties in order to gather information on the symptoms normally produced by the virus on these varieties.

RONCET, URTICADO, NETTLE LEAF OR REISIGKRANKHEIT.

The five year old Pinot Chardonnay vineyard at Saratoga in the Santa Clara Valley, California, reported by Hewitt and Winkler (1950) to be infected with a court-noué-like disease, was visited during May 1949 by the author in company with Dr. Hewitt. The disease was first observed in 1949. The new growth on the affected vines was severely stunted and the shoot internodes were

abnormally short and arranged in a zig-zag fashion (Plate 2A). Secondary shoots developed abnormally and some double or treble nodes with two or three buds at the same nodes were observed.

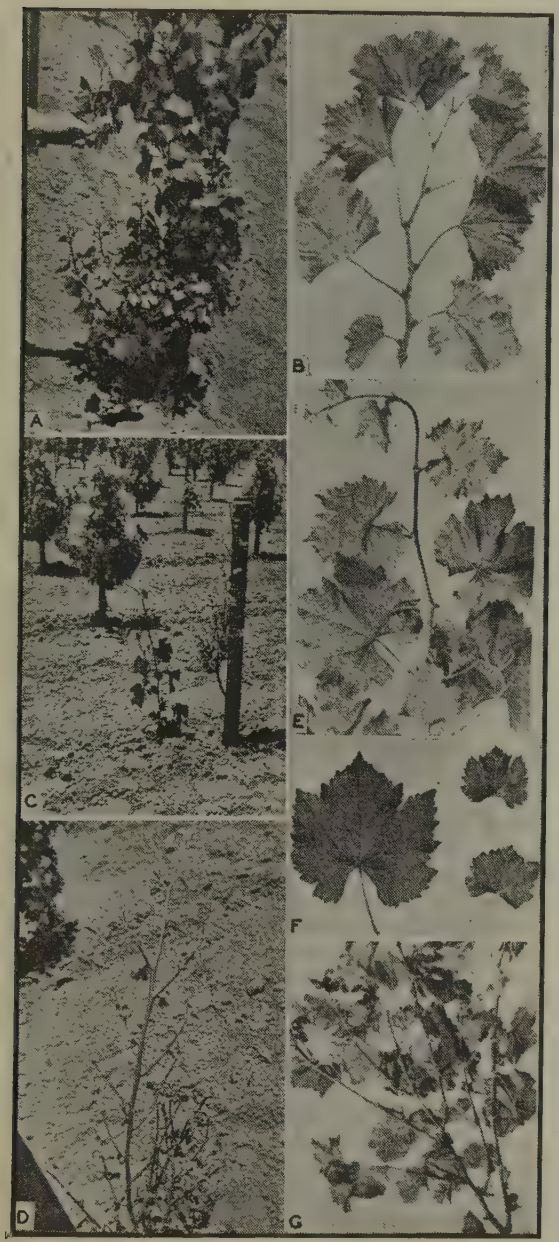

PLATE 2.—RONCET, URTICADO REISIGKRANKHEIT or NETTLE LEAF: A, *A Pinot Chardonnay vine at Saratoga in the Santa Clara Valley, California, partly stunted by roncet; stunted shoot held up next to the vine (25/5/1949).* B, *Malformation of Pinot Chardonnay leaves caused by roncet at Saratoga, California (Courtesy of Wm. B. Hewitt, 15/6/1949).* C, *Severe stunting of growth of a three year old French Colombard vine caused by roncet at Oakville in the Napa Valley, California; shoot inserted in the ground on the left is from an apparently healthy vine (24/5/1949).* D, *Abnormal branching and delayed foliation of French Colombard vines caused by roncet at Oakville, California (24/5/1949).* E, *Shoot of a healthy French Colombard vine at Oakville (Courtesy of Wm. B. Hewitt, 14/6/1949).* F, (*left*) *A leaf from a sound French Colombard vine and* (*right*) *two leaves from vines infected with roncet at Oakville, California (Courtesy of Wm. B. Hewitt, 14/6/1949).* G, *Excessive branching and small leaves on French Colombard at Oakville as a result of roncet; compare with shoot from sound vine shown in* E (*Courtesy of Wm. B. Hewitt, 14/6/1949).*

Most of the leaves on affected vines were somewhat smaller than the normal, possessed widened petiolar sinuses and the angles between the main and secondary veins, particularly those in the vicinity of the petiolar sinus, were comparatively acute. The leaf margins were considerably modified. The leaf incisions were apt to be deeper than the normal, the leaf points thereby becoming longer and more acute. The leaf margins became irregularly dentate-serrate or even dentate-laciniate instead of lobate-serrate.

The widening of the petiolar sinuses and the reduction of the areas between the main veins created the impression of a half-closed fan and resulted in some puckering or folding of the leaf tissues. Some clearing spots were observed on some of the malformed leaves, but they were not abundant and were not situated in any constant relation to the leaf veins. Some degree of vein clearing could be seen on most of the affected leaves. These leaf malformations were very pronounced on the older leaves during June (Plate 2B).

Poor setting of fruit noticeably reduced the crop borne on affected vines.

According to Hewitt and Winkler (1950), the affected vines grew fairly vigorously by midsummer. Towards September it became difficult to distinguish the infected from the sound vines. This was possible in many cases only after a very careful examination of the older foliage.

Hewitt and Winkler (1950) had reason to suspect that this disease, which was found also on Cabernet vines in an adjacent vineyard, might have been imported from France with the importation of vines some 65 years ago.

During this visit to California the author had the opportunity of examining vines of the French Colombard variety at Oakville in the Napa Valley which had been infected since 1948 (Hewitt and Winkler 1950) with a similar disease. The vines were three years old and the infected vines showed some most outstanding symptoms of severe stunting and poor foliation (Plate 2C and D). The leaves were small, crinkled and bronzy chlorotic, particularly around their margins. The internodes of the shoots were irregular and side shoots developed in abnormal abundance. According to Hewitt and Winkler (1950) the affected vines apparently recovered somewhat towards mid and late season. About a month after the author's visit, the leaves were fairly well formed but were dwarfed and had widened petiolar sinuses and reduced lobal indentations, very similar to those found on the Pinot Chardonnay variety (Plate 2 E, F and G).

Hewitt and Winkler (1950) were correct in considering the symptoms found in these vineyards to be very similar to those of roncet (commonly known as court-noué) found in vineyards of Europe, as will be indicated in the subsequent paragraphs.

In Portugal the author had ample opportunity of becoming acquainted with some of the most outstanding symptoms of a disease very similar to the one described and very aptly known there as " urticado ". Drs. Diaz and B. le'Oliviera were investigating this disease at the Estacão Agronómica Nacional at Sacavem. They showed the author some convincing experimental evidence on the transmissibility of the disease through approach grafting and by means of the insertion of tissue pieces from infected shoots into sound shoots, all transmission studies having been done from infected plants on to plants selected for soundness from stocks raised from seedlings in an insect-proof glasshouse. Some preliminary experiments, carried out by Dr. Diaz, were examined at Sacavem, which seemed to indicate that a *Pseudococcus* sp. might transmit the disease. Further experiments, however, were considered necessary to verify this hypothesis. The experience of the Portuguese investigators was that shading of the test plants accentuated symptom expression, conditions also favourable for the development of Pseudococcus.

Some very typical cases of natural infections with urticado were examined in the vicinity of Dios Portos on the Vital variety (Plate 3A), at Santarem and along the Duoro at Regua (Plate 3B). In all cases the dwarfing of the leaves, the disappearance of lobal leaf divisions, the general deepening of leaf indentations, the widening of petiolar sinuses and the narrowing of interveinal angles were very characteristic. In some cases leaves borne on certain sections of some vines showed these symptoms, whereas all the leaves of other vines were malformed. They were usually irregularly puckered,

PLATE 3.—RONCET, URTICADO, REISIGKRANKHEIT or NETTLE LEAF: A, *Grape vine at Dios Portos, Portugal, part of which is severely stunted by urticado and shows the typically malformed and stunted leaves (13/7/1949).* B, *A vine on the Northern banks of the Duoro at Regua, Portugal, with distinct urticado symptoms, but also with a moderate degree of mottling and interveinal and marginal drying of the leaves (19/7/1949).* C, D and E, *Vines on the Southern banks of the Duoro at Regua, Portugal, in which leaf malformation and mottling symptoms are very distinct, the latter being somewhat similar to the leaf mottling usually associated with Pierce's disease—compare Plate* 1C and E *(19/7/1949).*

and this characteristic together with the serrate, and at times almost thorny, leaf margins imparted the nettle leaf appearance to the foliage of infected vines.

In many cases mosaic-like symptoms were found on malformed leaves, but being unaware of the difference between roncet, mosaic and white mosaic symptoms at this stage, the author made no attempt to determine whether the true mosaic symptoms occurred here separately from urticado or not. The shoots of infected vines were short-noded and double nodes and double leaves were not very abundant.

On 19 July, 1949, the author visited some vineyards along the Southern slopes of the Duoro Valley near Regua, which showed symptoms rather similar to the leaf mottling described in Pierce's disease. These symptoms were observed on the varieties Tinta Amarela, Mourisco and Malvasia Preta. These vineyards, planted on terraced slopes containing the typical Duoro schist soils, were

apparently suffering badly and had many bare patches where vines had died off (Plate 3 E). The growth was somewhat stunted and the leaves showed a very distinct interveinal mottling and a severe scorch along their margins and ultimately in between the main veins (Plate 3 C and D). Most of the leaves of the affected vines tended to become puckered and to curl downwards. The shoots borne by severely affected vines were tender and somewhat stunted.

No indication could then be obtained about the probable cause of this condition, though information received was to the effect that the disease is apparently spreading and is becoming gradually worse. Some vineyards were visited on the same day on the Northern side of the Duoro where the vines were very severely affected and showed very typical symptoms of the urticado disease together with some leaf mottling and marginal drying similar to those found on the Southern slopes (Plate 3 B).

A copy of the photograph of the chlorotic leaves from the Duoro Valley was sent to Dr. Hewitt, who remarked that the interveinal clearing, marginal burning and rolling were typical of symptoms often associated with Pierce's disease. He indicated, however, that other environmental conditions might cause similar types of chlorosis, as already indicated. Further studies seem to be necessary to determine whether the disease on Tinta Amarela, Mourisco and Malvasia Preta is similar to the Pierce's disease or whether it is a condition resulting from " urticado " infected under the influence of particular environmental conditions.

No detailed information was available on the distribution of the disease in Portuguese vineyards, but judging from the situation of the cases of infection examined during the author's visit, the conclusion seems justified that the disease is probably fairly widely distributed in this country and that sufficient evidence exists on the importance of the disease.

In spite of information to the contrary, the author succeeded in locating a few cases in vineyards in the vicinity of Barcelona and Villafranca del Panades where vines showed disease symptoms very similar to those observed in Portugal and in California. The disease, however, could not easily be spotted while travelling alone and a closer examination of individual vineyards would probably reveal many more cases of infection. Most of the cases similar to court-noué, occurring in Spanish vineyards were apparently accepted by Spanish workers as cases of " false court-noué ", the result of defective growth conditions. It had been observed by workers at the Estacion de Viticultura y Enologia at Villafranca del Panades, however, that the disease mostly occurred when new vines had been planted on infected sites within five years after old or diseased vines had been uprooted. In cases where the intervening period approached seven years, during which grain or legumes were cultivated on the original infected sites, the disease was said to disappear.

Most of the research work of recent years in France on roncet (commonly known in France as " court-noué ") has been done by Prof. Branas and his associates at the Ecole d' Agriculture de Montpellier. Here the author enjoyed the opportunity of becoming thoroughly acquainted not only with roncet (court-noué), but also with two other diseases often closely associated with roncet, viz. mosaic and panachure, all of which are included under the name " dégénérescence infectieuse ", recently decided upon during a seminar arranged by the Office International du Vin in Paris (Anon. 1948).

The author, in company with Prof. Branas, fairly carefully examined some of the vineyards at Montpellier, Frontignan and Séte and the author enjoyed the assistance of Messrs. Pansiot and Sordel (Direction des Services Agricoles de la Cote-d'Or) when he examined some cases of infection in the vicinity of Dijon and Beaune. One of the greatest difficulties experienced during these examinations was to find separate vines showing the symptoms of either roncet, white mosaic or true mosaic only. Most of the infected cases showed symptoms corresponding to two or to all three disease types. Some of the most characteristic leaf symptoms of roncet were, however, found on the Muscat d'Alexandria and the Rupestris du Lot varieties.

Two types of leaf malformation were again very characteristic, particularly the formation of nettle-like leaves. In this case the leaf points were lengthened and sharpened, the petiolar sinuses were wide open, the lobes (or normally lobed leaves) were modified and the indentations often

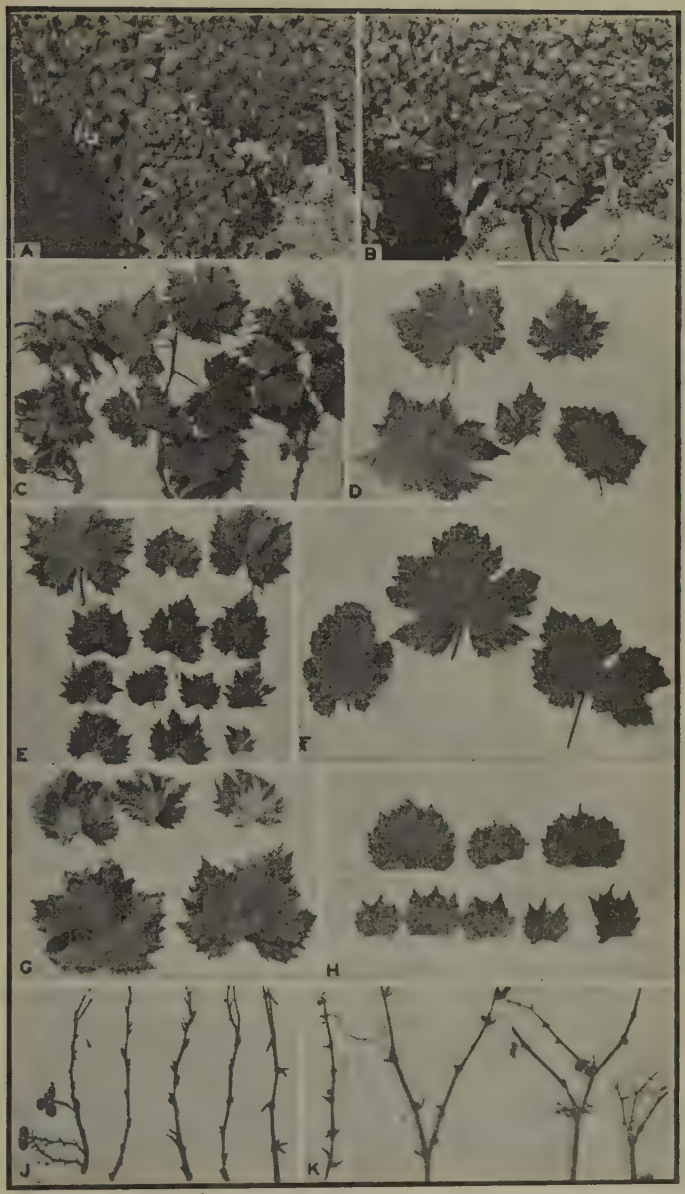

PLATE 4.—RONCET, URTICADO, REISIG-KRANKHEIT or NETTLE LEAF: A, *Pinot Chardonnay vine in the vicinity of Beaune infected with roncet as compared with healthy vines of the same variety shown in* B (*19/8/1949*). C, *Shoots of Muscat d'Alexandria with leaves malformed as a result of infection with roncet at Frontignan, France* (*4/8/1949*). D, *Leaves of Muscat d'Alexandria being double or assymmetrical as a result of roncet at Montpellier, France* (*2/8/1949*). E, *Leaves of Muscat d'Alexandria arranged from normal in order of degree of malformation to the parsley-like patterns; collected at Frontignan, France* (*4/8/1949*). F, *Upper leaf — apparently normal, lower left—beet leaf shaped, lower right —double leaf, as collected at Montpellier, France* (*2/8/1949*). G, *Leaves of Muscat d'Alexandria from Frontignan, France, deeply indented, sharply pointed (nettle-like) and rolled as a result of roncet infection* (*4/8/1949*). H, *Leaves of roncet-infected Rupestris du Lot vines at Montpellier (lower) compared with normal leaves in the upper row; third and fourth leaves in the lower row bear also spots typical of true mosaic* (*2/8/1949*). J, *Shoots of Muscat d'Alexandria; right shoot with normal nodal arrangement, four shoots on left with short internodes and abnormal shoot curvature* (*4/8/1949*). K, *Shoots of Muscat d'Alexandria showing severe fasciation (gabelung) on roncet infected vines at Montpellier* (*2/8/1949*).

deepened to such an extent that the leaves appeared to be tattered or parsley-like. These leaves were crinkled, had a hard texture, felt like bramble (roncée) and looked like nettle leaves (urticate), (Plate 4 C, E, G and H). Leaves malformed in this way were very common on infected vines and imparted a shrubby appearance to affected portions (Plate 4 A and B). Some leaves on roncet-infected vines were apt to develop asymetrically : the petiolar sinuses tended to close, double leaves developed, abnormal beet-like leaves were formed or one half of the leaf remained underdeveloped and stunted (Plate 4 D and F). These leaf malformations were not so common and were found mostly near the bases of affected shoots.

In spite of the difficulty experienced in finding the diseases separately on vines of the same variety to enable proper comparisons of symptoms, the author did come across some cases of infection in which these leaf malformations were not associated with any distinct mosaic-like discolourations. This suggested that roncet leaf malformations might possibly occur without distinct leaf clearing and that if mosaic symptoms were present, such would probably indicate a mixture of roncet and true mosaic infections (Plate 4 H). It is realised, however, that this point can be settled finally only by experiments for disease isolations.

The shoots borne on infected vines were typically short noded and showed a strong tendency to fasciation, dichotomously or even trichotomously (Plate 4 J and K). Double nodes were found almost without exception on infected vines, but were not very abundant.

The effects of millerandage and coulure were clearly evident on all infected vines and were sometimes severe even before the leaf symptoms became distinct.

The information received from Prof. Branas on the dependability of the endocellular cordons as a diagnostic characteristic of the disease is to the effect that experience in France has indicated that the presence of these cordons is not a satisfactory diagnostic symptom, even though it is regarded as dependable in Italy. His experience was that these cordons could not be found regularly in the wood of infected vines, and that they occurred in the wood of some varieties only.

Branas (1945) published some data to show the relative importance of " dégénérescence infectieuse " in Herault and Aude. Crop comparisons of the two periods 1920-29 and 1930-39 had shown a reduction in yield per hectare ranging up to 30 per cent., a reduction which he ascribed mainly to this disease. No disease survey had yet been made to determine the distribution of the disease in French vineyards. He estimated, however, that more than 50 per cent. of these vineyards were probably infected and that careful examinations would probably reveal that 70 per cent. of the French vineyards might be infected with one or more types of this disease complex. These facts and the difficulties generally experienced in the early diagnosis of the disease in vineyards very strongly emphasize its importance to European viticulture.

Several vineyards, presumably infected with roncet, were visited in Switzerland in the company of Drs. Terrier and Staehelin of the Station Federale d'Essais Viticoles, Arboricoles et de Chemie Agricole, Montagibert. It was immediately evident that the expression of symptoms as observed in vineyards in the immediate vicinity of Lausanne, St. Prex, Rolle and Nyon was much milder than that observed in all infected vineyards thus far visited. A general stunting effect was most general and leaf malformations were limited to a slight widening of the petiolar sinuses and slight modification of the leaf margins. Parsley- or double leaf types were not observed to occur. Short internodes, however, were fairly constantly found. In most cases the stunting symptoms were very closely associated with leaf mosaic, apparently the predominant disease in the vineyards examined.

It has been the general experience of the Swiss workers that roncet (or court-noué as it is generally known here) is hardly ever severe in Switzerland. No reason for this could be provided, either at Lausanne or at Wädenswil. The fact that this is the case in spite of the general practice followed by the Swiss viticulturists of obtaining most of their propogation materials from French nurserymen, has led to some considerable doubt amongst Swiss workers about the infectious nature of the disease. The tendency here is to support the auxin hypothesis or to believe that court-noué-like abnormalities are the result of malnutritional conditions. The author viewed some of the experimental plots containing series of grafted vines, in which evidence could be found, however, of a considerable

degree of transmission of these abnormalities from parental stock from even some of the clonal selections. In any case it did seem as if roncet is not very widely distributed or that it is of major importance in Swiss vineyards.

Most of the observations on roncet in Italian vineyards were made in Sicily, where some very striking examples were examined in the beginning of September 1949 by the author in company with Prof. Goidanich of the Republica Stazione di Patologia vegetale, Rome. The disease was found in very typical form in Palermo vineyards on the Perricone and the Chemminita varieties, on which the widened petiolar sinuses, the deeply serrated leaf margins and some leaf rolling were very characteristic and similar to cases of roncet observed in the other countries (Plate 5 A and B). The most striking leaf symptoms of roncet were found at Tenutella near to Catania on vines of *Vitis monticola*, the leaves of which were somewhat rolled, but were so deeply indented that the teeth were tapering to thorn-like points (Plate 5 C).

The shoots of all these vines showing roncet (arricciamento) leaf symptoms were short-noded, abnormally branched and sometimes double-noded (Plate 5 D). The crops of all diseased vines were affected at a very early stage and in a manner very similar to that noted for roncet in other infected vineyards.

According to information received in Rome, roncet appeared to be very generally distributed in Italian vineyards and was known to occur generally in the vineyards near to Bari and in Northern Italy.

Relatively little could be seen of the reisigkrankheit in the vineyards of the Rhineland. It was clear from the few cases seen and from the publications of Jöhnssen (1933), Maier (1939 a, b; 1943), Maier and Maier (1939, 1942), Schneiders (1936) and Stellwaag and Branas (1938) that this disease was very common in German vineyards and that most of the leaf symptoms described by the latter contributors correspond so closely to roncet, urticado or nettle leaf, that the reisigkrankheit could justifiably be considered to be similar (Branas, 1939 a).

A few very good specimens of vine seedlings showing leaf symptoms very similar to those of roncet were shown to the author by Dr. Husfeld at the Institut für Rebenzuchtung at Geilweilerhof, Siebeldingen (Plate 5 E). The affected seedlings were severely stunted and bore leaves which were asymmetrical and very deeply indented. Most of these seedlings never recovered and had to be eliminated from the breeding tests. The transmissibility of this disease, which was occasionally observed in the extensive breeding plots of this institute, has not yet been determined. The fact that Diaz found indications of the transmission of urticado by seed and that Branas reported seed transmission of roncet as a fairly common occurrence, lends support to the view that these seedlings might have become infected with the roncet virus from the seed.

No sign of the disease could be found on vines cultivated under glass at Ter Hulpe, near Brussels. This type of culture is, however, so intensive that it seemed doubtful whether any vine showing signs of strong deterioration, as would be the case with roncet, would be tolerated in the glasshouses for long, even though its cause might not be known.

WHITE MOSAIC OR PANACHURE.

The name white mosaic or panachure is used here for the disease similar to the mosaic described by Stranak, Blattny and Klecka (1931) and Smolak (1936). Prof. Branas at Montpellier first drew the author's attention to the fact that this mosaic was similar to a disease known in France as panachure and that true mosaic of vines as it occurred at Montpellier showed no albinose symptoms, but only clearing lesions very typical of most true mosaics described on other plants. Branas and Bernon (1937) found that panachure was graft transmissible and that the condition could be improved by spraying the foliage with lamp black, probably a screening effect from the sun.

Vineyards affected by a disease, according to Hewitt (1945) a graft-transmissible mosaic and closely related to the juice transmissible disease of Stranak et al. (1931), were shown to the author during his visit to California in May, 1949.

PLATE 5.—RONCET, URTICADO, REISIGKRANKHEIT or NETTLE LEAF: A, *Chemminita vine infected at Palermo, Sicily.* B, *Sharply indented leaves with widened petiolar sinuses borne by roncet-infected Chemminita vines at Palermo, Sicily (1/9/1949).* C, *Shoots of* Vitis Monticola *from Tenutella, Catania, Sicily, left—from an apparently healthy vine; right—from a vine infected with roncet (2/9/1949).* D, *Same shoots shown in* C, *defoliated to show the effect of roncet on the branching and nodal arrangement (2/9/1949).* E, *Vine seedlings grown at the Institut für Rebenzuchtung at Geilweilerhof, Landau; upper left—apparently healthy, upper right and lower two—seedlings showing various degrees of leaf malformation and stunting typical of roncet (reisigkrankheit) (17/9/1949)*

Different patterns of chlorosis were found to occur on the leaves of infected Cabernet and Pinot Chardonnay vines in the Santa Clara Valley. An irregular or a blotchy type of chlorosis developed over the entire leaf area, at times limited to particular portions of the leaves, but generally not margined by leaf veins (Plate 6 A and B). The colour of the tissues in the chlorotic areas very soon changed to a creamy white, but the green colour in the immediate vicinity of the leaf veins tended to persist, so that the green banded veins became accentuated in a creamy coloured background, a condition which is somewhat similar to chlorosis developing on calcareous soils.

In other cases a clearing or a gradual decolouration seemed to start at the veins and gave rise to outstanding, creamy white blotches. Upon enlargement these blotches formed albino bands along the veins or irregular patches sometimes bordered by veins. Neighbouring patches coalesced, until the entire leaf surface was involved (Plate 6 C).

Green islands of unchanged leaf tissues ultimately resulted, which diminished in size as the chlorotic areas enlarged. Many of the affected leaves ultimately lost all their green colour. In the advanced stages the colour of these leaves had a waxy white appearance. This differed distinctly from the most advanced types of calcareous chlorosis, in which a yellowish tint was retained until the end.

Hewitt (1945) first found the disease in 1943 on vines of the Palomino variety in the Napa Valley, but he had reason to believe that it was not yet generally distributed in Californian vineyards.

Symptoms extremely similar to the different types of white mosaic seen in California, were found at Vermelha (Cadaval, Portugal) and in several vineyards in the Tagus valley. The blotchy type of chlorosis was very distinct on the Vital variety at Vermelha (Plate 6 D), where albinosis occurred in a most typical form. Information was received here that the disease was first noticed on a few vines in the vineyard about ten years ago. It was estimated that approximately 500 vines were infected at the time of the author's visit. None of the neighbouring vineyards seemed to be infected. No case of white mosaic was found in the vineyards examined in Northern Portugal. It seems as if this disease is not yet very widely distributed in Portuguese vineyards.

From observations made while travelling from Madrid to Barcelona, the author concluded that white mosaic is extremely prevalent in vineyards situated between Reus and Barcelona. These observations were subsequently verified by closer inspections of several infected vineyards between Barcelona and Villafranca. On this occasion the author found excellent opportunities of distinguishing between calcareous chlorosis and white mosaic. All the characteristic types of albinosis were found intermingled on the same vines, the veinal albinosis being the most distinct (Plate 6 G).

White mosaic appeared to be very generally distributed in the environs of Montpellier, very often occurring together with roncet and true mosaic in the same vineyard. It seemed to be less common in vineyards surrounding Toulouse and Bordeaux and no case of white mosaic could be found between Cognac and Angouléme. Several very severe cases, however, were found in vineyards between Dijon and Beaune.

This disease was found to occur in very typical form on a large number of varieties, e.g. Muscat d'Alexandria, Pinot Noir, Aligote, Alvey Telegraph, Noah, and on many of the selections (212-7, 1305, 3-905, 601, 33 and Aramon Gansin No. 1). On all these varieties general chlorosis (Plate 6 E) and veinal clearing and albinosis (Plate 6 F) could be found.

It has been observed that leaves showing white mosaic symptoms might be dwarfed, if severe chlorosis had set in at an early stage. All infected leaves, however, retained their normal outline.

As some considerable importance was attached by many investigators to the diagnostic value of abnormally short internodes and of double nodes for the identification of roncet, some observations were made of the effect of diseases, other than roncet, on the regularity of length of internodes. In most cases difficulty was experienced in finding vines which showed only white mosaic and no roncet leaf symptoms. A few such cases, however, were found in the vineyards visited, in which so-called " court-noué " shoot symptoms (short internodes and zig-zag arrangement) were found associated with white mosaic leaf symptoms only. Double nodes were, however, much less common.

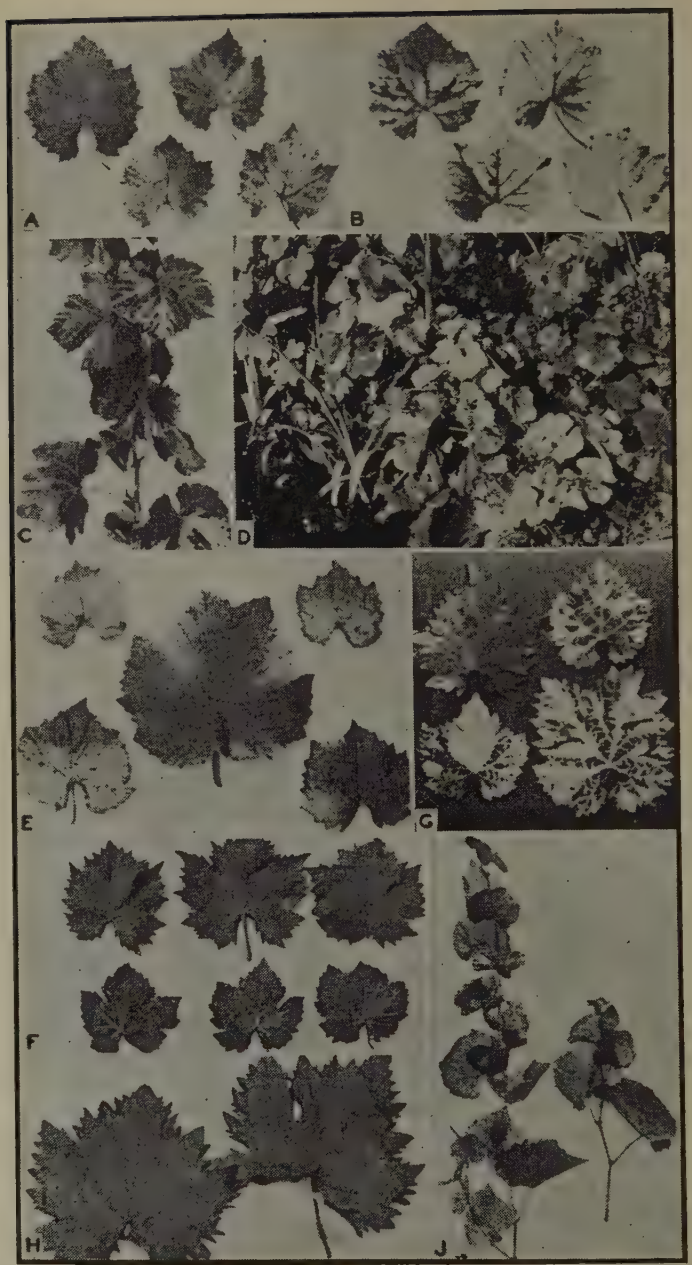

PLATE 6.—A to G, WHITE MOSAIC or PANACHURE: A, B, *Vine leaves from the Santa Clara County, California, irregularly mottled (Courtesy of Wm. B. Hewitt, 15/6/1949).* C, *A vine shoot with leaves showing vein clearing and veinal albinosis in various stages (Courtesy of Wm. B. Hewitt, 15/6/1949),* D, *Vines of the Vital variety at Vermelha, Cadaval, Portugal, with different patterns of very distinct albinosis on the leaves (13/7/1949).* E, *Vine leaves from Montpellier, France, with general mottling (2/8/1949).* F, *Leaves of Muscat d'Alexandria at Montpellier, France, (upper) from apparently healthy vines, (lower) from infected vines showing veinal whitening and slight dwarfing, but very little malformation (4/8/1949).* G, *Vine leaves collected in the vicinity of Villafranca del Panades, Spain, with very characteristic white mosaic symptoms (28/7/1949).* H and J, TRUE MOSAIC: *Vine leaves collected at Montpellier, France, and photographed with transmitted light (2/8/1949).*

Severe millerandage and coulure were the most distinct effects of the disease on the crops even at an early stage of infection.

Some of the most typical cases of white mosaic in Swiss vineyards were seen on the Chasselas variety at St. Prex. In some grafting experiments carried out by Mr. Staehelin, white mosaic and true mosaic were very clearly separated. These vines had been grafted during the preceding winter. The vines in rows from sound scions and grafts had grown vigorously. Those from white mosaic infected vines were stunted, short-noded and bore leaves with white mosaic symptoms. The vines originating from stock infected with true mosaic were equally stunted and short-noded, but their leaves developed true mosaic symptoms.

It should be mentioned, however, that white mosaic was found to occur much less severely and less commonly in the Swiss than in either the French, Spanish or Portuguese vineyards. The general chlorotic type of leaf decolouration was most common, whereas the blotchy type occurred in a very moderate form.

Information received at the Republica Stazione di Patologia Vegetale in Rome was to the effect that a few cases of panachure were known to occur in Italian vineyards. Only one case of infection with this disease was seen by the author and that was in a vineyard on the outskirts of Frascati near Rome. Some moderate cases of white mosaic were found at Tenutella in Sicily.

No trace of white mosaic could be found in the German vineyards visited in the Pfalz and in the Rhineland, neither could any information be obtained at Siebeldingen and at Geisenheim whether the disease was known to occur in Rhine vineyards.

Although very few investigators have studied this disease specifically, the available information leaves little doubt that the disease is graft-transmissible. In this connection it is interesting to note that Hewitt (1945) failed to transmit the disease with juice extracted from chlorotic leaves, leaving some doubt as to its juice-transmissibility as reported by Stranak et al. (1933). Petri (1932), reporting on some experiments carried out with mosaic (white mosaic) material received from Prof. Stranak, stated that the grafts from diseased plants grafted on American stocks lost the characteristics of mosaic and acquired those of arricciamento, indicating a very close analogy between the two diseases. Judging from his previous descriptions of the symptoms of the disease, it does appear that he probably experimented with material infected by both viruses, as he suspected. Petri (1932) further mentioned that Stranak and his associates demonstrated the transmission of the disease by the cocchineal (*Lecanium corni*) and by aphids. Transmission through soil could not be demonstrated.

TRUE MOSAIC.

The author first saw this disease in France and became acquainted with it during his discussions with Prof. Branas at Montpellier. Branas (1948) had then already drawn attention to this disease and reported success in separating mosaic from the roncet (court-noué) disease.

Leaves infected with mosaic showed very typical light transparent green spots, more clearly distinguishable in transmitted light (Plate 6 H and J). These spots might be more abundant in some parts of the leaf or might be fairly regularly distributed throughout the entire leaf. When young leaves near the growing tips were severely affected, the cleared lesions were apt to coalesce, resulting in green island formations in the midst of chlorotic areas. A considerable degree of vein clearing was visible in the worse affected leaves, but the cleared lesions were seldom situated in any definite relation to the leaf veins.

Where vines were infected with true mosaic only, the leaves generally retained their normal outline, though they might be considerably dwarfed and somewhat puckered as a result of severe infections. Very often, however, and particularly in the vineyards in the neighbourhood of Montpellier and Frontignan, true mosaic occurred so often together with roncet on the same vines, that roncet-like malformations might appear as a characteristic normally associated with true mosaic. (Plate 4 H.) A meticulous search through infected cases, however, revealed sufficient instances in which the true mosaic and the roncet could be found separately on vines of the same variety to

convince the author that these two diseases are distinctly different.

It was realised that somewhat similar chlorotic, mosaic-like spots were described by Hewitt et al. (1942) as early symptoms of the Pierce's disease and that some types of mosaic-like spots might possibly be associated with roncet infections as observed in the infected Pinot Chardonnay vineyard in California, but in both these cases mosaic was either not the predominant characteristic or ultimately developed into a symptom pattern entirely different from that on vines infected with true mosaic.

Severe infections with true mosaic cause a severe stunting of growth. Some very distinct court-noué-like shoot symptoms, irregularly short internodes and double nodes, are fairly common on such vines, though apparently not as common as on vines affected by roncet.

Some very distinct true mosaic symptoms were found on the Newman, Cynthiana, Etta, Rupestris du Lot, Bue Byer, Mobeetie, Novo Americana, Vinifera candicans and Wertussenin varieties grown at Montpellier.

True mosaic was very seldom found in the vineyards visited in other parts of France.

It did appear as if mosaic was more prevalent than either roncet or white mosaic in Swiss vineyards. The experiment at St. Prex in which Mr. Staehelin succeeded in separating true mosaic from white mosaic has already been referred to (vide p. 21), in which the severe stunting effect of true mosaic on young vines was clearly demonstrated. No information was, however, available on the general importance of this disease to Swiss viticulture, probably because of the lack of clear distinction between these different diseases and of the tendency to consider most of these types of degenerations as some type of " senescence ".

The most typical and severe cases of true mosaic were seen in Sicilian vineyards. Vines of the varieties Alicante Noir and Pergolese di Tivoli growing in the vicinity of Palermo and of the varieties Nerello and Berlandieri growing at Tenutella, near Catania, were very severely affected by the disease and showed all symptom types in a most characteristic manner. Leaf mosaic was very distinct and very similar to that observed at St. Prex and at Montpellier. The leaves with mosaic were irregularly puckered or rugose and their edges were apt to roll in towards the underside.

In all these vineyards the shoot symptoms were court-noué-like in many respects. Double nodes and several types of shoot fasciation were as abundant in these vineyards as in most roncet infected vineyards thus far examined.

There is very little doubt that Pantanelli (1911 p. 10) had similar cases in mind when he referred to one of the stages of roncet as " mosaico della vite " on account of the similarity of this phase to tobacco mosaic. According to Petri (1937) the mosaic to which Pantanelli referred, differed distinctly from the one from Bohemia (white mosaic), but was in some respects similar to arricciamento.

Little information could be obtained on the prevalence of the disease in Italian and Sicilian vineyards, but considering its period of existence in Italy, it seems likely that it is probably fairly generally distributed.

Although very little experimental evidence exists on the transmissibility of this disease, the author, judging from such evidence as had been obtained by Branas (1948) and by Staehelin on this disease, and from the general appearance of this disease, has very little doubt about its virus origin. Further work, however, is considered necessary to provide sufficient evidence for this assumption and to determine its relations to and interaction with the other virus diseases described in this contribution.

LEAF ROLL OR ROLLERKRANKHEIT.

A few vines showing leaf roll very similar to that described by Maier (1939) and Stellwaag (1948) as rollerkrankheit were seen in vineyards of Montpellier. Prof. Branas informed the author, however, that he had failed to effect its transmission through grafting.

This type of leaf roll differs distinctly from the type found on the leaves of vines suffering from

roncet. None of the observations could support the view expressed by Schneiders that this type of leaf roll is one of the phases of reisigkrankheit.

Though the name " arricciamento " sometimes used by Petri for roncet implied leaf rolling as one of the symptoms, the moderate leaf rolling observed on roncet vines at Palermo and Catania always occurred on leaves with the deep indentations and other malformations so very typical of roncet.

Some of the most typical symptoms of leaf roll or rollerkrankheit as described and illustrated by Maier (1939) were seen in the middle of September, 1949, in the experimental vineyards at the Versuchs- und Forschungsanstalt fur Wein-, Obst- und Gartenbau at Geisenheim am Rhein. The edges of most of the leaves of affected vines were very severely rolled downwards towards the mid-rib (Plate 7 A and B), but the leaves were neither dwarfed nor malformed to any extent similar to the leaf malformations so characteristic of roncet (see Plates 3 and 4). At this stage the surfaces of rolled leaves were somewhat glossy and showed advanced stages of discolouration particularly in the areas between the main veins, predominantly yellow on Sylvaner leaves and purplish red on the Portuguese variety. Those on adjoining vines were still green. Apart from this, the vines grew and cropped apparently normally and, according to Prof. Stellwaag, the bearing capacity of vines was seldom seriously diminished.

Stellwaag (1948) failed to find any indication that rollerkrankheit was related to reisigkrankheit. In 1939 he grafted scions from Sylvaner vines showing leaf roll symptoms on sound 5BB and G1 rootstocks and sound Sylvaner scions on infected stocks. Some signs of leaf roll were evident between 1939 and 1944 on vines in these series. Those of all the check vines remained free from leaf roll. All these vines, however, grew apparently normally during 1945 and 1946. He obtained some indications that this condition might be propagated by budding and grafting, but failed to find reliable evidence that it was transmitted from affected to sound vines. He, therefore, concluded: " Man kann sonach die Blattrollerkrankheit nicht als an und für sich ansteckend betrachten " (Stellwaag 1948).

According to Stellwaag (1948), Scheu estimated that 80 per cent. of the German vineyards were affected by rollerkrankheit. The position in connection with this disease in European vineyards, however, is still so uncertain that no reliable information could be gathered on its distribution and general importance.

An abnormality very similar to that examined at Montpellier and Geisenheim has been located recently in some South African vineyards and it is suspected that more cases will be found in future. No information is yet available as regards its relative importance or its transmissibility.

WITCHES' BROOM.

This is the name tentatively suggested for a disease shown to the author by Mr. Staehelin in a Chasselas and a Sylvaner vineyard at St. Pierre de Cloges in the Rhone Valley. All the leaves of affected vines were chlorotic in a severe degree and appeared to be very similar to calcareous chlorosis. Chlorosis started in the interveinal areas and spread throughout the leaves until only narrow green stretches bordered the main veins. The leaf margins and the interveinal tissues were severely scorched, resulting in a marginal curling and an irregular puckering of the leaves (Plate 7 H, J and K). The leaves and shoots furthermore were severely stunted. The internodes were considerably shortened and irregular, at times double noded, and cases of fasciation and superfluous branching occurred in abundance. (Plate 7 J). All the shoots were abnormally light coloured. The general appearance of affected vines was that typical of a stunted type of witches' broom. Most of the blossoms borne by affected vines were abortive and the crops were greatly reduced at a fairly early stage of the disease.

None of the leaf symptoms typical of the diseases thus far described, nor of acariose could be identified on these vines. To all appearances this condition, though showing all the shoot symptoms previously accepted as characteristic of court-noué, differed distinctly from any diseased condition seen anywhere.

PLATE 7.—A and B, LEAF ROLL or ROLLERKRANKHEIT. A, *Vine infected at Geisenheim, Germany (19/9/1949).* B, *Severe rolling of the leaves typical for Rollerkrankheit (Courtesy of F. Stellwaag).* C, D and E, DISTORTION DISEASE. C, *Abnormal foliage and shoot formation caused on Berlandieri vines at Catania, Sicily.* D, *Normal growth on uninfected Berlandieri vines.* E, *Fasciation, abnormally long internodes and dwarf shoots arising at a multiple node of the infected shoots shown in* C *(2/9/1949).* F, " ARREPOLLADO de los brotes producido por el ataque de Empoasca libyca " *(Reproduced from* Estación de Fitopatol. Agric de Madrid, Trabajos (Serie Fitopatol.) núm. 101). G. to K, WITCHES' BROOM. G, *A young vine severely stunted in the neighbourhood of Wädenswil, Switzerland (12/9/1949).* H, *One of the vines infected at St. Pierre de Cloges in the Rhone Valley, Switzerland (25/8/1949).* J, *A shoot from infected vine shown in* H *with short internode, abnormally tender side shoots and poorly coloured, burnt and curled leaves (25/8/1949).* K, *An apparently healthy vine at St. Pierre de Cloges and adjacent to the one shown in* H *(25/8/1949).*

Mr. Staehelin's information on this case was that the condition was first noticed five years ago in this vineyard and that it had gradually spread to neighbouring vines, totalling about 500 at the time of the author's visit.

Yet another case of witches' broom was found to occur in a vineyard along the borders of Lake Zürich near Wädenswil. Only one vine showed symptoms similar to those observed in the Rhone Valley (Plate 7 G).

According to Drs. Blumer and Peyer from the Eidgenossen Versuchsanstallt at Wädenswil, this disease was first noticed on one vine two years ago. It was then uprooted. One of the adjoining vines in the same row then contracted the disease and was promptly removed. The vine shown in Plate 7 G was the third diseased case which developed. The vines surrounding this vine appeared to be perfectly normal and without any sign of calcareous chlorosis, as was the case in the Rhone Valley.

It should be mentioned that this disease appears to be very similar to one described and illustrated by Castro (1943) as occurring in vineyards of Almeria (Plate 7 F). He ascribed this disease to the effects of infestation by *Empoasca libyca*, a homopterous insect, reported to have been the cause of considerable damage.

Castro (1943) reported that the symptoms observed in Spain seem to correspond to those due to many different causes such as mosaic, alkali injury, " arrepollado " or " nodo curto ". Regarding the immediate cause of this condition he stated: " Opiniones diversas existen respecto a la causa inmediata de los daños que ocasionan los ataques de especies afines a la *Empoasca libyca*, unos entomólogos los atribuyen a las picarduras del insecto, mientras otros estiman que este es simplemente un vector de virus. Aunque no se han realizado experiencias concluyentes, es muy probable que las alteraciones de los organos foliáceos sean debidas tan sólo al efecto toxico de las picaduras del tiflocíbido, como sucede con otros hemípteros y tisanópteros . . . "

As far as can be ascertained (Faes, Staehelin and Bovey, 1948) *Empoasca libyca* is not known to occur in Swiss vineyards. Furthermore the rate of spread of the disease as observed in the Rhone Valley and in the vineyard near Wädenswil is such that it seems to exclude the possibility of its being a direct result of attacks by any insect, unless it is a sedentary or a very slowly migratory type. The behaviour of the disease in the Swiss vineyards is considered to be very suggestive of an infectious disease, probably of a virus type. This case warrants further research.

DISTORTION DISEASE.

While examining some cases of mosaic during the beginning of September, 1949, in vineyards in the neighbourhood of Tenutella (near Catania, Sicily) Prof. Goidanich and the author came across some Monticola and Berlandieri vines affected in a rather unusual manner. The vines showed some signs of gigantism and at the same time some of nanism.

All the leaves on affected vines were puckered and curled in every imaginable manner, most common being that obviously resulting from an extension of leaf tissue being held back by the main veins. Many of the leaves showed a tendency to roll downwards and backwards from their tips and towards the leaf petioles (Plate 7 C and D). The petiolar sinuses were wide and in many cases reduced to mere petiolar adhesion depressions. The leaf margins were considerably modified, the lobate divisions having disappeared almost entirely and the normal leaf teeth having been reduced to a few major teeth. The texture of the leaves was hard and the leaves from affected plants felt definitely thicker than those from vines of the same variety which did not show the disease. The colour of these leaves was dark green and no sign of mosaic could be found on them.

The internodes of the shoots were either abnormally long or otherwise abnormally short, particularly those which arose from the multiple nodes (Plate 7 E). The former yielded shoots which seemed to be rather bare and sparsely covered with curly leaves and the latter yielded bushy heads with clumps of distorted leaves. The affected vines bore practically no crop or only a few scraggy bunches.

The symptoms of this disease could be compared very well with those of roncet and true mosaic, which occurred in very typical form on these and other varieties on the same property. It could then be determined that those of the distortion disease differed distinctly from those of any of the other diseases seen here or in any of the other countries. There were a few cases where some of the leaf distortions, in which incisions were apt to be deeper than the normal, seemed to approach those characteristic of roncet ; such cases, however, were exceptional. Whereas the general impression of a bramble-like or nettle-like growth was created by typical roncet infections, that created by the distortion disease was one of a crazy growth. This might be considered as a form of " rachitismo " referred to by Pantanelli and Petri, but whenever this term was used by them the further description of the symptoms illustrated leaf symptoms typical of roncet.

Symptom expression of the distortion disease gave the impression of its being a systemic and infectious disease. Detailed observations of the factors which may possibly be held responsible for this abnormality could not be made on the spot. This case seems to be so severe and so interesting that it definitely warrants further investigation. The possibility that this disease may be the result of a simultaneous infection with different viruses should be borne in mind.

ABNORMALITIES SYMPTOMOLOGICALLY RELATED TO THE VIRUS DISEASES.

ACARIOSE OR KRAUSELKRANKHEIT.

According to Prof. Osterwalder, early Swiss workers used the name court-noué almost entirely for an abnormal condition caused in vines by the mite *Phyllocoptes vitis*. This condition later became known as acariose, the name court-noué having become more and more applied to the disease now better known as roncet.

Some very typical cases of acariose were examined at Rolle, near Lausanne, where its symptoms could be compared with those of true mosaic on adjacent vines. The symptoms were most distinct on young leaves, which were crinkled and had semi-translucent spots with small necrotic dots clearly visible on the underside of the leaves.

In this case infestation with the mite was too moderate to have had any serious effect on the crop, or on the vigour and hence the nodal length of the shoots. Petri (1934 a) described and illustrated some severe cases of acariose in which the shoots were severely stunted and bore short internodes, often somewhat similar to those typical of roncet.

HORMONE EFFECTS.

Occurrence as a Result of Artificial Treatments.

Nysterakis (1945, 1947, 1948), in a series of contributions on the effect of phytohormones on the vine, produced evidence to support his view that " le rabougrissement de la vigne, communément appelé " court-noué " est dû directement á un déséquilibre hormonal, susceptible d'être provoqué dans certains cas, par un parasite, dans d'autres, par un agent non parasitaire." Staehelin, working at Lausanne, was inclined to support the hypothesis of Nysterakis. He found that early foliage applications of the herbicide 2-4, D caused severe foliar malformations, but that applications later in the season produced effects only during the following season. His treatments showed that vines were so sensitive to these phytohormones that they developed typical symptoms for more than one season in succession, when soils were treated. Severe millerandage was one of the first defects shown by treated vines. Topi and Baldacci (1949) described the vine foliar and shoot malformations resulting from treatments with 2-4, D in some considerable detail and compared these with the symptoms of roncet (arricciamento). They then raised the question whether the causal virus might not be responsible for some disturbance in the distribution of auxins in the plants and hence the similar symptom expressions.

The author was fortunate in having been able to inspect several vineyards in the neighbourhood of Beaune, Lausanne, Rome and Wädenswil showing the effects of treatments with herbicides, particularly 2-4, D. In all these cases the foliar malformations were very characteristic, but in all cases distinctly different from that caused by any of the diseases described in the preceding paragraphs.

The petiolar sinuses widened as a result of the treatment and the veins became seriously disorganized, the normal vein arrangement having been changed to an irregular and longitudinal network of rather prominent and cleared veins, situated so closely together in severe cases that the

PLATE 8.—PHYTOHORMONE INJURY. A and B, *Vine shoots and leaves at Wädenswil, Switzerland, typically malformed by an application of 2-4, D herbicide (spray blotches are residues of Bordeaux mixture) (photos taken for the author by R. Isler, Eidg. Versuchsanstallt, Wädenswil, 13/9/1949).* C, *" Franzenblattrigkeit " on vine leaves collected in a vineyard which had received no phytohormone treatment (Courtesy of F. Stellwaag).* D, *Leaf malformation caused by applications of Weedone at Frascati, Rome (Courtesy of E. Baldacci).* E, *Malformed leaves and double nodes on a vine at St. Pierre de Cloges in the Rhone Valley, Switzerland, not treated with any of the herbicides (25/8/1949).*

mesophyll tissues were almost entirely eliminated. The affected leaves lost their normal lobate-dentate outline and assumed an inverted triangular shape with the dentations more and more apt to develop on the upper leaf edge only. These dentations were either slender and pistillate or, and most commonly, fragmentarily dentate. (Plate 8 A, B and D.) Some deep incisions from the outer margin sometimes developed, but these usually created the impression of rupture more than of indentation. At times such incisions were so pronounced that irregularly lobated leaves were the result, somewhat reminiscent of the " persillage " leaf stage of roncet.

Tender shoots, short internodes and double nodes were shoot symptoms very regularly found on hormone treated plants (Plate 8 A and D), characteristics which were considered by many to be typical also of roncet. Infertility of the blossoms on affected vines resulted in a considerable reduction of the crop.

Occurrence in Nature.

While examining vines in the vicinity of the vineyard affected by the witches' broom disease in the Rhone Valley, the author found a Chasselas vine bearing a single shoot with symptoms rather similar to those on vines treated with phytohormones (Plate 8 E). This shoot was severely stunted, bore irregular internodes and some double nodes. The basal and apical leaves were deformed to long-stemmed, triangular leaf remnants, in which the veins were drawn so closely together that the mesophyll tissues occurred only as isolated islands. The apical leaf edges were irregularly fringed and sometimes constricted to form a sheaf-like bundle. The leaves borne on the middle nodes showed different degrees of malformation, varying from a slight rolling to a severe contortion as a result of abnormal vein arrangement and development. As far as could be determined, vines in this vineyard and the environment had not been treated with any of the herbicides.

Petri (1912) in one of his early contributions on roncet published a photograph of a vine shoot with symptoms almost identical to those illustrated in Plate 8 E and described above. Petri referred to this case as a specimen of reisigkrankheit received from Germany. He did mention, however, that such cases were said to be extremely rare in German vineyards.

Prof. Stellwaag showed the author some specimens of vine material collected during 1925 in a vineyard at Geisenheim on which leaf abnormalities (Plate 8 C) of the same type as those described and illustrated by Topi and Baldacci 1948 (Plate 8 D) and the fringed semi-circular upper leaf margin were particularly characteristic. This type of malformation was referred to by Schneiders (1936) and Stellwaag (1948) as " Fransenblattrigkeit ". According to Schneiders this had previously been erroneously identified as roncet. The fringed leaves occurred only on isolated shoots and were considered by Stellwaag (1948) to originate as bud mutations resulting from generative disturbances. Short internodes and in exceptional cases double nodes might be co-symptoms of this abnormality.

These facts indicate that leaf abnormalities, extremely similar to those seen on vines injured by phytohormones and those reported by Nysterakis (1945, 1947, 1948) and Topi and Baldacci (1948) can occur on vines under natural conditions. This seems to justify the conclusion that this phenomenon may be caused by some natural disturbance of hormone distribution in the plant.

Short or irregular internodes and double nodes, like infertility, coulure and millerandage occur as co-symptoms in so many different diseases and abnormalities, that it does not seem justifiable to extend the conclusion arrived at in the previous paragraph to include roncet. The author has no doubt that the leaf symptoms caused by the hormone disturbances are so characteristic and so distinctly different from those of roncet, that the two abnormalities cannot be considered analogous.

SUMMARY AND CONCLUSIONS.

Close observation of symptom peculiarities and very careful distinction between symptomological characteristics are generally accepted as the most essential requirements for the approach to virus disease problems and for virological research.

The symptomology of Pierce's disease appears to be fairly well-known. Some considerable confusion, however, has existed in connection with the diagnosis of and distinction between some of the other diseases of vines, attributed to viruses and related troubles. In many cases this confusion seems to be due to a misunderstanding about the relative value of the different symptom characteristics and to the simultaneous occurrence of several diseases in so many European vineyards.

Actually the relative diagnostic value of the different symptoms can be properly evaluated only after the different diseases have been clearly distinguished from one another. Some attempts have been made in this direction, but it does seem that the bases for differentiation should be reviewed in order to enable a more reliable separation of abnormalities. The available information on research and the observations on these diseases reported above seem to justify the following remarks.

(1) Endocellular cordons.

Although the literature contains several reports indicating the abnormal abundance of endocellular cordons in the tissues of plants suffering from roncet, several workers have found them to be present, though in a lesser degree, in tissues of apparently normal plants. Before these cordons can be accepted as a reliable basis for the early diagnosis of the disease, their prevalence in all the abnormalities, showing shoot symptoms similar to those of roncet, should be thoroughly investigated and compared with their prevalence in tested healthy tissues.

(2) Infertility, Coulure and Millerandage.

It has been indicated that strong effects of infertility, coulure and millerandage are evident as very early symptoms on vines suffering from roncet, white mosaic, true mosaic, leaf roll disease, witches' broom, distortion disease and on those showing signs of hormone injury. This characteristic evidently cannot be accepted as indicating infection with any particular disease.

(3) Short Internodes, Double Nodes and Fasciation.

It has long been realised by many workers that these symptoms can be found on vines not suffering from roncet. The general tendency, however, seems to be particularly strong to accept the presence of irregular internodes and of double nodes as some of the most characteristic and most reliable diagnostic symptoms of roncet. This tendency has probably been encouraged by the fairly general acceptance of the name " court-noué " (" no curto " in the Portuguese and " nudo corto " in the Spanish language) to indicate this disease.

The observations reported in this contribution clearly indicate the fairly common occurrence of these shoot abnormalities on vines affected not only by roncet but also on those affected by white mosaic, true mosaic, witches' broom and the distortion disease. Such symptoms obviously cannot be accepted as diagnostic characters for any of these diseases. The acceptance of these symptoms as of main diagnostic importance may further result in an over-emphasis of the importance of other factors in studies on the aetiology of these diseases.

It may have been observed that the author has refrained from using the name " court-noué " for the roncet disease. This was done intentionally in order to avoid confusion and to promote a clear distinction between the different abnormalities. For this same reason also it is suggested that " court-noué " should not be used to designate any of the diseases in which short internodes or double nodes are co-symptoms.

(4) Leaf Symptoms.

Double leaves were found only on vines showing roncet symptoms, but these leaves were sparse and fairly difficult to find. From the descriptions and illustrations presented in this contribution it is clear that each of the diseases and abnormalities shows general leaf symptoms which are very distinct and constant, a fact which was particularly noticeable in the case of diseases which occurred and could be seen in different countries, namely roncet, white mosaic, true mosaic and leaf roll

(rollerkrankheit). These are essentials which make these leaf symptoms reliable for identification and differentiation.

On this basis mainly it is suggested that these diseases be separately designated as:—

(*a*) *Pierce's Disease* occurring in California and the Argentine.

(b) *Roncet, Urticado, Nettle Leaf or Reisigkrankheit* occurring in California, Portugal, Spain, France, Switzerland, Italy (including Sicily) and Germany and probably in several other European countries.

(*c*) *Panachure or White Mosaic* occurring in California, Portugal, Spain, France, Switzerland, Italy and according to reports also in Bulgaria and Czecho-Slovakia.

(*d*) *True Mosaic* occurring in France, Switzerland and Italy.

(*e*) *Leaf Roll or Rollerkrankheit* occurring in France, Switzerland and Germany.

(*f*) *Witches' Broom* occurring in Switzerland.

(*g*) *Distortion disease* occurring in Sicily.

Mention should be made of the fact that not one of these diseases was observed in the vineyards visited during a short visit to Vinelands in Canada.

(5) Dégénérescence Infectieuse.

Considering the immense primary importance of differentiation between the different diseases to promote and stimulate further research on the many unsolved problems in connection with them, it seems unfortunate that a recommendation to use the all-inclusive designation of " dégénérescence infectieuse " (Gallay, 1947, Anon. 1947) was recently made. It is realised that the problem of eliminating the propagation of these viruses through planting material may seem similar, yet it is not. Scientific requirements demand the most effective distinction between various types of abnormalities, until experimental facts have shown that some abnormalities are variations of some type, are due to mixtures of infective agents or to the influence of environmental or occur as a result of varietal influence. It is actually only after such distinctions have been made that the question of vectors can be fruitfully investigated.

The following aspects therefore appear to be some of those which warrant particular emphasis in future research projects dealing with the virus and similar diseases of the vine.

(a) Separation of and distinction between these different diseases and abnormalities, in which it is hoped that this contribution may be of some assistance.

(b) A study of symptom expression of these diseases transmitted under controlled experimental conditions to different varieties and the determination whether certain vine varieties are tolerant of or resistant to any of them.

(c) Studies on variations of symptoms which may occur as a result of mixed viral infections.

(d) Effect of environmental conditions on symptom expression.

(e) Investigations on ways of transmission of the different diseases and collection of direct experimental evidence on soil and insect transmission.

Meanwhile South African viticulture may consider itself fortunate in being, as far as is known at present, still free from all these diseases, with the exception of leaf roll, a condition which will receive some further attention in future. The South African privilege obviously calls for suitable measures to guard against possible introduction of these diseases in the future.

ADDENDUM

White Mosaic was recently identified by the author on several Cabernet Sauvignon vines growing at Stellenbosch.

In conclusion the author wishes to express his sincerest appreciation to all those who contributed so much to the success of his tour and who gave him every possible assistance, as well as permission to use information and photographs put at his disposal.

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